APPENDIX IV

3. Testing Certificate for Land-based Test

Certificate No. : KOMERI-A-09T725

시 험 성 적 서
Certificate of Test

1. 신 청 자 *Applicant*

ㅇ **회사명** : 21st Century Shipbuilding Co., Ltd. *Name*

ㅇ **주 소** : 14-1, Bongpyeong-dong, Tongyoung-si, Gyeongnam-do, 650-140, Korea

ㅇ **접수일자** : Oct. 5. 2010 *Date of Receipt*

2. 시험대상품 *Equipment Under Test*

ㅇ **시험품명** : Ballast Water Management System (full-scale) *Name of Product* ㅇ **모 델** : "ARA Ballast" *Model*

3. 성적서 용도 : Efficacy testing *Purpose of Certificate of Test*

4. 시험규격 : *Test Standards* The Provisional Regulation of Type Approval of Ballast Water Management System by Ministry of Land, Transport and Maritime Affairs (No. 2009-566), Methods in accordance with the requirements of G8 (IMO Res. MEPC. 174(58), ANNEX 4, PART 4, 4.8)

5. 시험환경 : *Environment* ㅇ Temperature : (20.0 ± 1.0) °C , ㅇ Relative Humidity : (40 ± 5) % R.H.

6. 시험기간 : Nov. 6. 2009 ~ Jan. 12. 2010 *Test Period*

7. 발행일자 : Mar. 5. 2010 *Issued Date*

8. 시험결과 : **PASS** *Test Result*

Mar. 5. 2010

Prepared by Documentation Specialist
Name : Sang-Hee Baek

Approved by Quality Manager
Name : Jae-Uk Kang

한국조선기자재연구원
Korea Marine Equipment Research Institute

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Tel:+82-51-400-5000 Fax:+82-51-400-5091
http://www.komeri.re.kr

TEST REPORT

1. APPLICANT INFORMATION

Company : 21st Century Shipbuilding Co., Ltd.

Address : 14-1, Bongpyeong-dong, Tongyoung-si, Gyeongnam-do, 650-140, Korea

Name of Client : Shin Boung Cheul

Telephone : +82-70-7018-8400

Facsimile : +82-55-641-8408

2. MANUFACTURER INFORMATION

Company : 21st Century Shipbuilding Co., Ltd.

Address : 14-1 Bongpyeong-dong, Tongyoung-si, Gyeongnam-do, 650-140, Korea

Telephone : +82-70-7018-8400

Facsimile : +82-55-641-8408

3. LABORATORY INFORMATION

Laboratory : Korea Marine Equipment Research Institute

Address : 1125-22, Dongsam-Dong, Youngdo-Gu, Busan, 606-806, Korea

Telephone : +82-51-400-5000

Facsimile : +82-51-400-5091

4. EQUIPMENT UNDER TEST (EUT) INFORMATION

EUT Name : Ballast Water Management System (full-scale)

Model : "ARA Ballast"

Serial No. : -

Power : -

5. TEST SUMMARY

No.	Test Item	Test Standard	Result
1	**> 32 PSU TEST 1 cycle 5 period**	- pH: Standard Method 4500 H^+B (APHA, 2005) - Water temp: Standard Method 2550 (APHA, 2005) - DO: Standard Method 4500-O G (APHA, 2005) - Turbidity: Standard Method 2130 B (APHA, 2005) - Salinity: Standard Method 2520 B (APHA, 2005) - DOC and POC: ISO 8245 (2004) - TSS: Standard Method 2540 D (APHA, 2005) - Viable organism (≥ 10~50 μm): Fluorescein dying with 5'-CFDA AM (Anja et al., 2005), Standard Method 10200 C (APHA, 2005), Culture methods (Manual and Guide, UNESCO, 2005) - Viable organism (≥ 50 μm): Staining method (Tang et al., 2006), Standard Method 10200 C (APHA, 2005) - Heterotrophic bacteria: Standard Method 9215 - Total Coliform and *Escherichia coli*: US EPA 1603 (2006) - Intestinal *Enterococci*: US EPA 1600 (2006) - Toxicogenic *Vibrio cholerae*: Standard Method 9260 H (APHA, 2005) and/or API 20E kit (BioMerieux, Inc.)	**PASS**
2	**> 3-32 PSU TEST 2 cycle 5 period**		

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1. LAND-BASED TEST

1.1 TEST ENVIRONMENT

- Ambient temperature (20.0 ± 1.0) ℃
- Relative Humidity (40.0 ± 5.0) % R.H.

1.2 TEST STANDARD

· Test standard used in this test is adequate to the Provisional Regulation for Type Approval of Ballast Water Management System by Ministry of Land, Transport and Maritime Affairs (No. 2009-566), Methods in accordance with the requirements of G8 (IMO Res. MEPC. 174(58), ANNEX 4, PART 4, 4.8) and details as below;

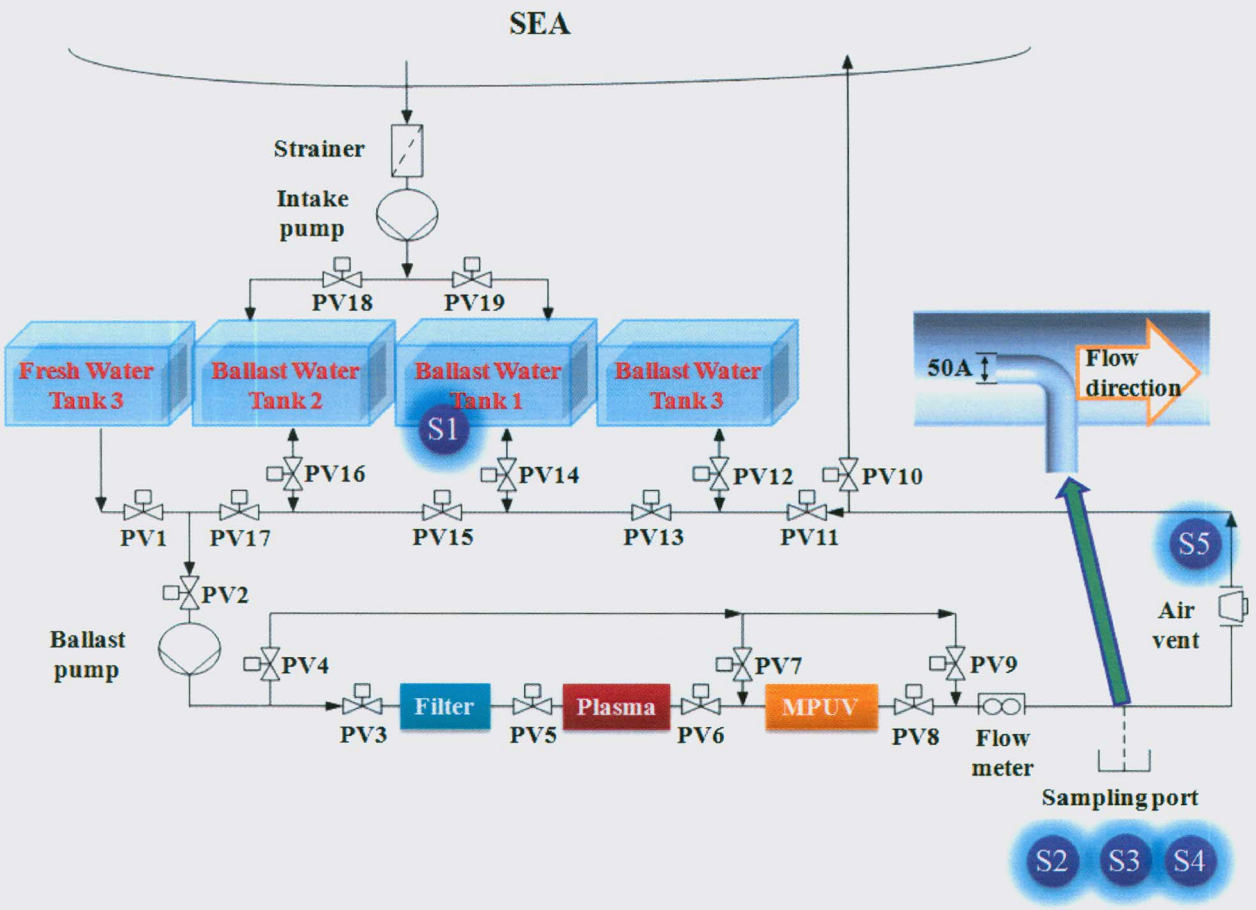
- pH: Standard Method 4500 H^+B (APHA, 2005) - Measurement with Electrode multiprobe (Hydrolab, USA)
- Water temperature: Standard Method 2550 (APHA, 2005) - Measurement with Electrode multiprobe (Hydrolab, USA)
- DO: Standard Method 4500-O G (APHA, 2005) - Measurement with Electrode multiprobe (Hydrolab, USA)
- Turbidity: Standard Method 2130 B (APHA, 2005) - Measurement with Electrode multiprobe (Hydrolab, USA)
- Salinity: Standard Method 2520 B (APHA, 2005) - Measurement with Electrode multiprobe (Hydrolab, USA)
- DOC and POC: ISO 8245 (2004)
- TSS: Standard Method 2540 D (APHA, 2005)
- Viable organism (≥ 10~50 μm): Fluorescein dying with 5'-CFDA AM (Anja et al., 2005), Standard Method 10200 C (APHA, 2005), Culture methods (Manual and Guide, UNESCO, 2005)
- Viable organism (≥ 50 μm): Staining method (Tang et al., 2006), Standard Method 10200 C (APHA, 2005)
- Heterotrophic bacteria: Standard Method 9215
- Total Coliform and *Escherichia coli*: US EPA 1603 (2006)
- Intestinal *Enterococci*: US EPA 1600 (2006)
- Toxicogenic *Vibrio cholerae*: Standard Method 9260 H (APHA, 2005) and/or API 20E kit (BioMerieux, Inc.)

1.3 TEST EQUIPMENT

	Description	Manufacturer	Model Number	Calibration Due
◆	Multiprobe (Hydrolab)	Hach	DS-5	-
◆	Fluorescent microscope (Scale bar)	Olympus	CKX41	-
◆	Stereo-microscope	Olympus	SZ40	-
◆	Sedgewick-Rafter counting chamber	-	-	-
◆	Hemacytometer	-	-	-
◆	Bogorov counting chamber	-	-	-
◆	Incubator (micro algal)	DS Sci.	250 L	~ 2009. 12. 24
◆	Incubator (bacterial)	HB Sci.		~ 2009. 12. 24
◆	Clean bench	SY Sci.	SH-150S	-
◆	Clean room	-	10,000 class	-
◆	Dry oven	BINDER	ED240	~ 2009. 12. 24
◆	Image analyzer	BAUMER	TDI DMC3	-
◆	Image analyzer	Dixi Optics	JUJAK 5.5	-
◆	Electronic balance	OHAUS	Adventureth	~ 2009. 12. 24
◆	Autoclave	Hirayama	HVE	~ 2009. 12. 24
◆	Standard sieve	DH Sci.	50 μm	~ 2009. 12. 24
◆	Plankton net (10 μm, 50 μm)	Aqua Net (DK)	10 μm, 50 μm	-
◆	Auto pipette	Axygen	AX-10000	~ 2013. 02. 20
◆	Auto pipette	Axygen	AX-1000	~ 2013. 02. 20
◆	Colony counter	SUNTEX	570	-

1.4 TEST SET-UP

· Schematic diagram of the Land-based test shows as below. Water sample collected from the sampling ports S1 to S5.



Fige 1-1. Schematic process diagram of the land-based test facility of the "ARA Ballast" BWMS and Sampling port installed in a pipe.

1.5 TEST PROCEDURE

See Appendix II PROCEDURES OF LAND-BASED TEST.

1.6 TEST SCHEDULE

Cycle	Period	Test date		Salinity
		Ballasting	De-ballasting	
1	1	06. Nov. 2009	11. Nov. 2009	34.09
	2	12. Nov. 2009	17. Nov. 2009	34.15
	3	19. Nov. 2009	24. Nov. 2009	34.36
	4	26. Nov. 2009	01. Dec. 2009	34.45
	5	03. Dec. 2009	08. Dec. 2009	34.57
2	1	10. Dec. 2009	15. Dec. 2009	23.62
	2	17. Dec. 2009	22. Dec. 2009	23.01
	3	24. Dec. 2009	29. Dec. 2009	22.09
	4	31. Dec. 2009	05. Jan. 2010	22.71
	5	07. Jan. 2010	12. Jan. 2010	23.43

1.7 CRITERIA OF TEST FOR LAND-BASED TEST

1.7.1 CRITERIA OF TEST WATER

Test item	Requirement		Remarks
Viable organism ≥ 50 μm	> 1 × 10^5 individuals/m^3, 3 phylum 5 species in minimum		IMO MEPC. 53/24, /Add.1 ANNEX 3, Part 2-2.3.19 ~ 2.3.20
Viable organism ≥ 10-50 μm	> 1 × 10^3 individuals/mL, 3 division 5 species in minimum		
Heterotrophic bacteria	> 1 × 10^4/mL		
Dissolved Organic Carbon(DOC) Particulate Organic Carbon (POC)	> 32 PSU	> 1 mg/L / > 1 mg/L	IMO Res. MEPC.174(58) Guideline (G8)의 2.3.17
	> 3-32 PSU	> 5 mg/L / > 5 mg/L	
Total Suspended Solid (TSS)	> 32 PSU	> 1 mg/L	
	> 3-32 PSU	> 50 mg/L	

1.7.2 CRITERIA OF TREATED WATER

Test item	Requirement	Remarks
Viable organism (≥ 50 μm)	< 10 individuals/m^3	IMO BWM/CONF/36, Regulation D-2
Viable organism (≥ 10-50 μm)	< 10 individuals/mL	
Escherichia coli	< 250 cfu/100 mL	
Intestinal *Enterococci*	< 100 cfu/100 mL	
Toxicogenic *Vibrio cholerae*	< 1 cfu/100 mL	

1.7.3 VALIDATION TEST CONDITION

Test item	Requirement	Remarks
Viable organism (≥ 50 μm)	≥ 100 ind./m^3	IMO MEPC. 58/23/ ANNEX 4, Part 2, 2.2.2.5
Viable organism (≥ 10-50 μm)	≥ 100 ind./mL	

1.8 RESULTS

1.8.1 TEST WATER

(1) Basic parameter of test water

Cycle	Period	DOC	POC	TSS	Remarks
1 (> 32 PSU)	1	1.67	2.25	34.10	PASS
	2	1.94	1.39	27.10	PASS
	3	2.70	1.22	28.00	PASS
	4	1.71	1.30	23.30	PASS
	5	2.85	1.77	27.50	PASS
2 (> 3 - 32 PSU)	1	9.60	14.50	51.30	PASS
	2	9.52	14.50	59.70	PASS
	3	9.13	15.50	61.60	PASS
	4	9.50	13.70	52.90	PASS
	5	10.3	16.50	61.60	PASS

(2) Density of organisms of test water

Cycle	Period	≥ 50 μm organisms	≥ 10-50 μm organisms	Heterotrophic bacteria	Remarks
1 (> 32 PSU)	1	138 250	3 077	32 500	PASS
	2	128 000	1 603	19 773	PASS
	3	252 660	1 483	18 000	PASS
	4	139 250	1 639	16 727	PASS
	5	509 100	1 949	9 409	PASS
2 (> 3 - 32 PSU)	1	436 500	1 974	20 227	PASS
	2	387 000	1 748	11 954	PASS
	3	425 000	1 593	13 772	PASS
	4	307 000	3 132	16 090	PASS
	5	301 000	1 358	16 863	PASS

1.8.2 NUMBER OF VIABLE ORGANISMS

(1) Viable organisms ≥ 50 μm (inds./m^3)

Period	1 cycle		2 cycle	
	Untreated water	Treated water	Untreated water	Treated water
1	1.03×10^3	0.00	3.00×10^4	0.00
2	1.44×10^5	0.00	6.33×10^3	0.33
3	4.59×10^4	2.67	6.03×10^4	0.00
4	6.79×10^4	0.67	2.00×10^4	0.00
5	7.16×10^4	0.67	6.83×10^3	0.00

* Data indicates an arithmetic mean.

(2) Viable organisms ≥ 10 - 50 μm (inds./mL)

Period	1 cycle		2 cycle	
	Untreated water	Treated water	Untreated water	Treated water
1	6.95×10^2	5.00	7.51×10^2	6.33
2	1.19×10^2	0.33	8.16×10^2	2.67
3	5.41×10^2	5.33	8.75×10^2	7.00
4	4.04×10^2	1.67	1.19×10^3	2.00
5	4.28×10^2	3.33	6.75×10^2	0.67

* Data indicates an arithmetic mean.

(3) BACTERIA GROUP

Period	Test item	1 cycle		2 cycle	
		Untreated water	Treated water	Untreated water	Treated water
1	Toxic *Vibrio cholerae* (cfu/100 mL)	0	0	0	0
	Intestinal *Enterococci* (cfu/100 mL)	110	0	11	0
	Escherichia coli (cfu/100 mL)	0	0	0	0
2	Toxic *Vibrio cholerae* (cfu/100 mL)	0	0	0	0
	Intestinal *Enterococci* (cfu/100 mL)	0	0	12	0
	Escherichia coli (cfu/100 mL)	0	0	0	0
3	Toxic *Vibrio cholerae* (cfu/100 mL)	0	0	0	0
	Intestinal *Enterococci* (cfu/100 mL)	0	0	1	0
	Escherichia coli (cfu/100 mL)	0	0	0	0
4	Toxic *Vibrio cholerae* (cfu/100 mL)	0	0	0	0
	Intestinal *Enterococci* (cfu/100 mL)	48	0	17	0
	Escherichia coli (cfu/100 mL)	0	0	0	0
5	Toxic *Vibrio cholerae* (cfu/100 mL)	0	0	0	0
	Intestinal *Enterococci* (cfu/100 mL)	3	0	4	0
	Escherichia coli (cfu/100 mL)	0	0	0	0

* Data indicates an arithmetic mean.

1.8.3 NUMBER VIABLE ORGANISMS OF UNTREATED WATER

(1) Viable Organism ≥ 50 μm (inds./m^3)

Period	1 cycle	2 cycle
1	1.03×10^4	3.00×10^4
2	1.44×10^5	6.33×10^3
3	4.59×10^4	6.03×10^4
4	6.79×10^4	2.00×10^4
5	7.16×10^4	6.83×10^3

(2) Viable Organism ≥ 10-50 μm (inds/mL)

Period	1 cycle	2 cycle
1	6.95×10^2	7.51×10^2
2	1.19×10^2	8.16×10^2
3	5.41×10^2	8.75×10^2
4	4.05×10^2	1.19×10^3
5	4.28×10^2	6.75×10^2

1.9 CONCLUSION :

· Tests were performed in accordance with the requirements of the *Guidelines for approval of ballast management system* (IMO Res. MEPC. 174(58), Annex 4) and Regulation D-2 (BWM/CONF/36). Test results show that the Land-based test of 21st Century Shipbuilding Co., Ltd. ("ARA Ballast") mets the ballast water performance standard D-2 of the IMO ballast water management convention.

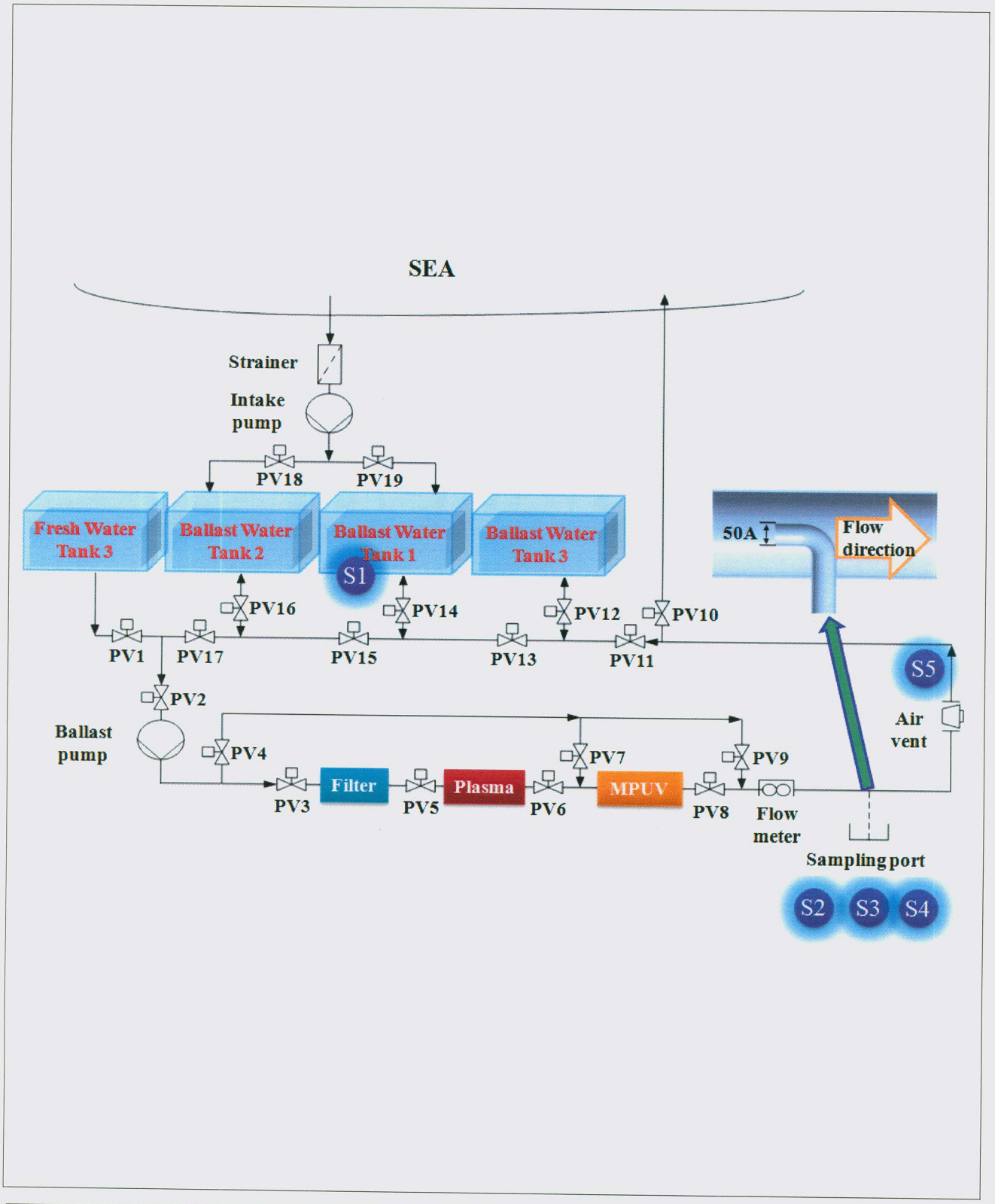
Salinity	Period	Test duration (Ballasting to De-ballasting)	Results (Reg. D-2)	Valid condition (Reg. D-2.1) (IMO Res.MEPC. 174(58) ANNEX 4 Part 2-2.3.36)
34 PSU	1	06. Nov. 2009 - 11. Nov. 2009	PASS	PASS
	2	12. Nov. 2009 - 17. Nov. 2009	PASS	PASS
	3	19. Nov. 2009 - 24. Nov. 2009	PASS	PASS
	4	26. Nov. 2009 - 01. Dec. 2009	PASS	PASS
	5	03. Dec. 2009 - 08. Dec. 2009	PASS	PASS
20 PSU	1	10. Dec. 2009 - 15. Dec. 2009	PASS	PASS
	2	17. Dec. 2009 - 22. Dec. 2009	PASS	PASS
	3	24. Dec. 2009 - 29. Dec. 2009	PASS	PASS
	4	31. Dec. 2009 - 05. Jan. 2010	PASS	PASS
	5	07. Jan. 2010 - 12. Jan. 2010	PASS	PASS

박정경 김영수

Tested by : Jeong-Kyeong Park **Technical Manager : Young-Soo Kim**

APPENDIX

Ⅰ. DRAWING OF EQUIPMENT UNDER TEST



II. PROCEDURE OF LAND-BASED TEST

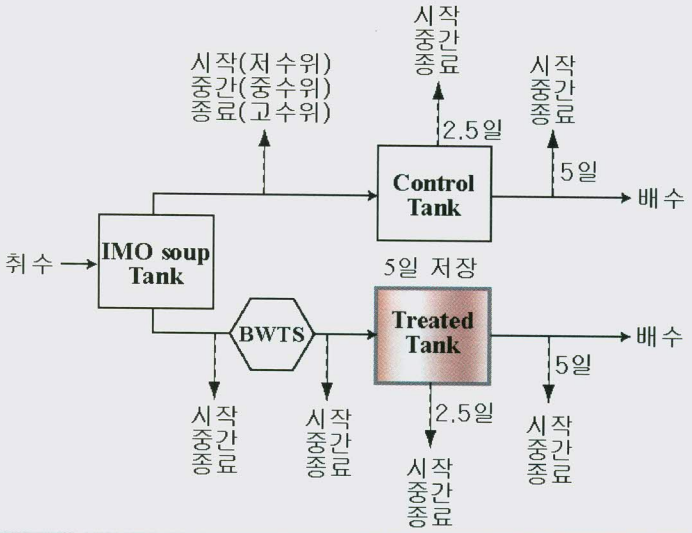
KOMERI SOP BWMS 01
Rev 0.0
June 2008

BWMS Test Procedure on Land-Based Test

유효한 시험 기준 (IMO soup)

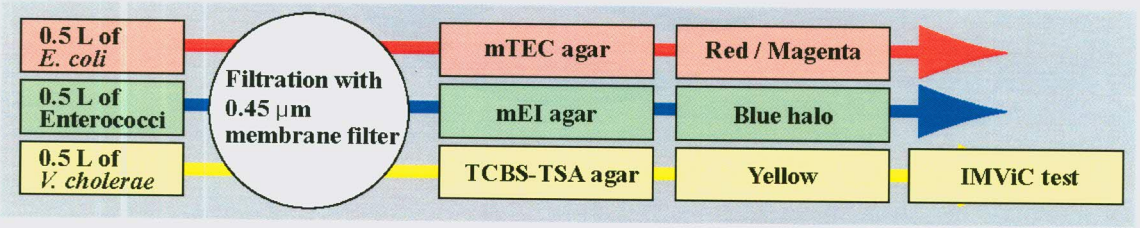
Organism > 50 μm	3 div. 5 spp., > 10^6 ind./m^3
Organism 10 ~ 50 μm	3 phy. 5 spp., > 10^4 ind./mL
Heterotrophic bacteria	10^4 living cells/mL

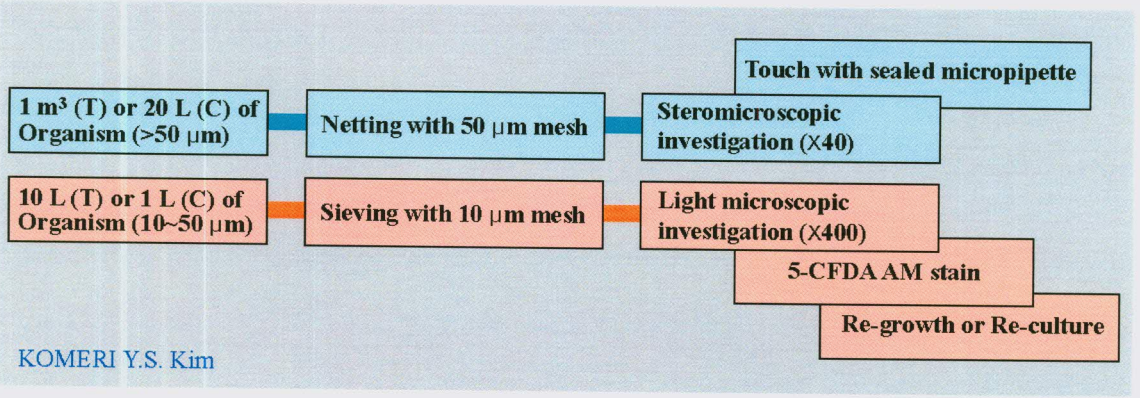
	Salinity		
	> 32 PSU	3~32 PSU	< 3 PSU
DOC	> 1 mg/L	> 5 mg/L	> 5 mg/L
POC	> 1 mg/L	> 5 mg/L	> 5 mg/L
TSS	> 1 mg/L	> 50 mg/L	> 50 mg/L



동시 측정 항목

1. pH
2. Water temperature
3. Salinity
4. DO
5. TSS
6. DOC
7. POC
8. Turbidity





III. TYPE OF VIABLE ORGANISMS IN THE TEST WATER

1 Cycle (> 32 PSU)

1 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp.
		Chaetocerotales	*Bacteriastrum hyalinum*
			Chaetoceros sp.
		Lithodesmidales	*Ditylum* sp.
		Melosirales	*Stephanopyxis* sp.
		Fragilariales	*Asterionellopsis glacialis.*
		Naviculales	*Pleurosigma* sp.
	Euglenozoa		
	Unidentification diatom		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Paracalanus sp.
			Centropages abdominalis
		Harpacticoida	*Microstella* sp.
		Cyclopoida	*Oithona* sp.
		Copepod nauplius	-
	Mollusca	Bivalve larvae	-
	Annelida	Polychaeta larvae	-
	Unidentified 1		
	Unidentified 2		

1 Cycle (> 32 PSU)

2 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
		Chlamydomonadales	*Brachiomonas* sp.
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Chaetocerotales	*Chaetoceros* sp.
		Naviculales	*Pleurosigma* sp.
		Bacillariales	*Pseudo-nitzchia* sp.
		Fragilariales	*Asterionellopsis glacialis.*
	Euglenozoa		
Viable organisms ≥ 50 μm	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Paracalanus sp.
			Pseudodiaptomus marinus
		Cyclopoida	*Oithona* sp.
		Sessilia	Balanus larvae
		Copepoda nauplius	-
		Copepodite	-
		Cladocera	*Evadne* sp.
		Harpacticoida	-
	Mollusca	Bivalve larvae	-
	Platyhelminthes	Turbellarian	Müller's larvae
	Annelida	Polychaeta larvae	-

1 Cycle (> 32 PSU)

3 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
		Chlamydomonadales	*Brachiomonas* sp.
	Bacillariophyta	Lithodesmidales	*Ditylum* sp.
		Chaetocerotales	*Chaetoceros* spp.
		Naviculales	*Pleurosigma* sp.
	Euglenozoa		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Eurytemora pacifica
			Paracalanus sp.
			Pseudodiaptomus marinus
		Cyclopoida	*Oithona* sp.
		Sessilia	Balanus nauplius
		Harpacticoida	-
		Copepodite	-
		Copepoda nauplius	-
	Mollusca	Bivalve laevae	-
	Platyhelminthes	Turbellarian	Müller's larvae
	Annelida	Polychaeta larvae	-

1 Cycle (> 32 PSU)

4 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
		Chlamydomonadales	*Brachiomonas* sp.
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Melosirales	*Stephanopyxis* sp.
		Naviculales	*Pleurosigma* sp.
		Chaetocerotales	*Chaetoceros* spp.
	Metacylis mediterranea(세모발)		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Protozoa	Tintinnida	*Tintinnopsis* sp.
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Pseudiaptomus marinus
			Paracalanus sp.
		Harpacticoida	-
		Cyclopoida	*Oithona* sp.
		Sessilia	Balanus nauplius
		Copepod nauplius	-
	Mollusca	Bivalve laevae	-
	Annelida	Polychaeta larvae	-
	Platyhelminthes	Turbellarian	Müller's larvae
	Chaetognatha	Aphragmophora	*Sagitta crassa*

1 Cycle (> 32 PSU)

5 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
	Dinophyta	Gymnodiniales	*Gymnodinium* sp.
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Thalassionemales	*Thalassionema* sp.
		Chaetocerotales	*Chaetoceros* spp.
	Unidentification diatom		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Pseudodiaptomus marinus
		Harpacticoida	-
		Cyclopoida	*Oithona* sp.
		Sessilia	Balanus nauplius
		Copepodite	-
		Copepoda nauplius	-
	Chrysophyta	Coscinodiscales	*Coscinodiscus* sp.

2 Cycle (> 3 - 32 PSU)

1 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
		Chlamydonoadales	*Brachiomonas* sp.
	Dinophyta	Gymnodiniales	*Gymnodinium* sp.
	Bacillariophyta	Leptoculindrales	*Leptocylindrus* sp.
		Thalassionemales	*Thalassionema* sp.
		Naviculales	*Pleurosigma* sp.
	Unidentification diatom		
Viable organisms ≥ 50 μm	Rotifera	Monogononta	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Cyclopoida	*Oithona* sp.
		Harpacticoida	-
		Copepoda nauplius	*Oithona* sp.
		Sessilia	Balanus nauplius
		Copepodite	-
		Copepoda nauplius	-
	Mollusca	Bivalve larvae	-

2 Cycle (> 3 - 32 PSU)

2 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
	Heterokontophyta	Dictyochales	*Dictyocha* sp.
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Naviculales	*Pleurosigma* sp.
			Amphiprora sp.
		Lithodesmidales	*Ditlyum* sp.
	Euglenozoa		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Centropages abdominalis
		Harpacticoida	-
		Cyclopoida	*Oithona* sp.
		Sessilia	Balanus nauplius
		Copepodite	-
	Chrysophyta	Coscinodiscales	*Coscinodiscus* sp.
	Mollusca	Bivalve larvae	-

2 Cycle (> 3 - 32 PSU)

3 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Chaetocerotales	*Chaetoceros* spp.
		Lithodesmidales	*Ditlyum* sp.
	Euglenozoa		
Viable organisms ≥ 50 μm	Rotifera	Monogononta	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
		Cyclopoida	*Oithona* sp.
		Copepoda nauplius	-
		Copepodite	-
	Chrysophyta	Coscinodiscales	*Coscinodiscus* sp.

2 Cycle (> 3 - 32 PSU)

4 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Chaetocerotales	*Chaetoceros* spp.
		Melosirales	*Stephanopyxis* sp.
	Dinophyta	Gymnodiniales	*Gymnodinium* sp.
	Euglenozoa		
	Metacylis mediterranea		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calanoida	*Acartia omorii*
			Paracalanus sp.
		Harpacticoida	-
		Cyclopoida	*Oithona* sp.
		Sessilia	Balanus larvae
		Copepoda nauplius	-
		Copepodite	-
	Chrysophyta	Coscinodiscales	*Coscinodiscus* sp.

2 Cycle (> 3 - 32 PSU)

5 period	Phylum/Division	Order	Genus/Species
Viable organisms ≥ 10 - 50 μm	Chlorophyta	Chlorodendrales	*Tetraselmis suecica*
	Bacillariophyta	Thalassiosirales	*Thalassiosira* sp..
		Chaetocerotales	*Chaetoceros* spp.
		Lithodesmidales	*Ditlyum* sp.
	Euglenozoa		
Viable organisms ≥ 50 μm	Rotifera	Ploimida	*Brachionus plicatilis*
	Arthropoda	Anostraca	*Artemia salina*
		Calnoida	*Acartia omorii*
			Centropages abdominalis
		Harpacticoida	-
		Cyclopoida	*Oithona* sp.
		Copepoda nauplius	-
		Copepodite	-
	Chrysophyta	Coscinodiscales	*Coscinodiscus* sp.

IV. TEST RESULT DETAILS

> 32 PSU from 6 November to 11 November

1 cycle 1 period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	16.71	17.02	17.03	17.09	16.97	16.94	16.97
pH	8.49	8.53	8.54	8.55	8.49	8.50	8.51
ORP (mV)	416	434	428	420	404	370	397
Salinity (psu)	34.11	34.23	34.24	34.26	34.09	34.13	34.13
DO (mg/L)	7.82	7.97	7.83	7.61	7.91	7.94	7.80
Turbidity (NTU)	13.40	12.60	12.80	12.20	13.80	13.40	12.10
Total suspended solid (mg/L)	34.10	29.90	33.90	31.10	34.50	33.90	35.10
Dissolve organic carbon (mg/L)	1.67	1.64	1.53	2.13	1.71	2.37	2.14
Particulate organic carbon (mg/L)	2.25	1.83	1.78	1.64	2.60	2.05	1.79
Organism (≥ 50 μm)	138 250	31 470	31 500	27 500	0	0	0
Organism (≥ 10-50 μm)	3 077	2 278	2 150	2 077	157	239	236
Heterotrophic bacteria (cells/mL)	32 500	27 273	33 909	31 273	870	750	367
Total coliform (cfu/mL)	0	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	3	1	1	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	10	25	11	13	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

1 cycle 1 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	16.68	16.73	16.72	16.79	16.83	16.90
pH	8.03	8.08	8.12	8.18	8.21	8.22
ORP (mV)	436	439	441	424	428	424
Salinity (psu)	34.06	34.09	33.83	34.14	34.15	34.12
DO (mg/L)	7.19	7.50	7.49	7.82	7.75	7.64
Turbidity (NTU)	7.77	8.51	7.03	10.80	11.00	10.30
Total suspended solid (mg/L)	24.10	21.30	20.70	27.50	30.00	34.70
Dissolve organic carbon (mg/L)	1.79	1.73	1.79	2.55	2.46	2.45
Particulate organic carbon (mg/L)	0.10	0.10	0.11	0.83	0.26	0.21
Organism (≥ 50 μm)	12 330	8 000	10 580	0	0	0
Organism (≥ 10-50 μm)	784	770	532	6	7	2
Heterotrophic bacteria (cells/mL)	15 318	27 955	24 000	310	0	10
Total coliform (cfu/mL)	55	45	35	0	0	0
Escherichia coli (cfu/100 mL)	0	0	1	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	10	192	129	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

> 32 PSU from 12 November to 17 November

1 cycle 2 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	16.06	16.05	16.00	15.95	16.31	16.33	16.38
pH	7.99	8.02	8.02	8.03	7.98	7.99	7.97
ORP (mV)	564	507	513	514	531	507	503
Salinity (psu)	34.39	33.92	33.99	33.98	34.30	34.33	34.37
DO (mg/L)	8.21	8.42	8.24	8.07	8.32	8.27	8.17
Turbidity (NTU)	11.40	19.30	19.15	18.70	11.60	12.10	11.80
Total suspended solid (mg/L)	27.10	35.50	33.20	31.20	24.40	26.10	28.10
Dissolve organic carbon (mg/L)	1.94	1.66	1.72	1.70	2.56	2.59	2.62
Particulate organic carbon (mg/L)	1.39	2.10	1.53	1.81	0.65	0.45	0.82
Organism (≥ 50 μm)	128 000	286 500	304 830	320 000	0	0	0
Organism (≥ 10-50 μm)	1 603	1 596	1 374	1 355	119	105	147
Heterotrophic bacteria (cells/mL)	19 773	35 682	28 455	25 864	63	110	87
Total coliform (cfu/mL)	560	545	550	600	0	0	0
Escherichia coli (cfu/100 mL)	6	4	9	4	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

1 cycle 2 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	12.30	12.10	12.31	12.49	12.48	12.42
pH	7.78	7.78	7.82	7.67	7.73	7.75
ORP (mV)	523	521	509	559	537	535
Salinity (psu)	33.96	34.02	33.96	34.21	34.23	34.26
DO (mg/L)	8.79	8.76	8.68	8.56	8.71	8.62
Turbidity (NTU)	11.80	9.99	10.90	6.86	6.61	6.43
Total suspended solid (mg/L)	20.30	14.10	15.70	9.20	33.50	8.90
Dissolve organic carbon (mg/L)	2.15	2.04	2.00	2.15	2.14	2.14
Particulate organic carbon (mg/L)	0.18	0.27	0.35	0.13	0.23	0.17
Organism (≥ 50 μm)	154 500	132 500	145 500	0	0	0
Organism (≥ 10-50 μm)	132	104	120	1	0	0
Heterotrophic bacteria (cells/mL)	31 636	39 318	32 681	86	46	3
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	0	0	0	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

> 32 PSU from 19 November to 24 November

1 cycle 3 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	12.40	12.67	12.69	12.63	12.47	12.49	12.67
pH	8.05	8.06	8.05	8.05	8.05	8.02	8.02
ORP (mV)	517	505	508	512	508	504	504
Salinity (psu)	34.40	34.42	34.42	34.46	34.42	34.49	34.39
DO (mg/L)	9.10	8.96	8.86	8.66	8.96	8.84	8.66
Turbidity (NTU)	9.60	14.90	14.80	14.90	10.30	9.65	9.85
Total suspended solid (mg/L)	28.00	31.30	30.10	31.10	21.50	41.30	22.80
Dissolve organic carbon (mg/L)	2.70	2.76	2.77	2.80	2.78	2.69	2.71
Particulate organic carbon (mg/L)	1.22	1.89	1.78	1.44	1.26	1.73	1.53
Organism (≥ 50 μm)	252 660	226 330	225 830	254 660	0	3	0
Organism (≥ 10-50 μm)	1 483	1 223	1 188	1 102	96	76	88
Heterotrophic bacteria (cells/mL)	18 000	21 318	23 590	21 727	210	250	50
Total coliform (cfu/mL)	0	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	1	1	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

1 cycle 3 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	9.85	9.90	9.86	9.86	9.78	9.66
pH	7.80	7.82	7.88	7.67	7.67	7.74
ORP (mV)	572	565	548	607	596	589
Salinity (psu)	34.35	34.29	34.39	34.09	34.22	34.24
DO (mg/L)	9.11	9.12	9.04	8.82	8.96	9.02
Turbidity (NTU)	8.09	7.88	7.27	6.14	5.76	6.18
Total suspended solid (mg/L)	16.10	18.00	16.80	16.40	14.30	14.10
Dissolve organic carbon (mg/L)	2.04	2.03	2.07	2.25	2.22	2.17
Particulate organic carbon (mg/L)	0.25	0.42	0.44	0.41	0.39	0.38
Organism (≥ 50 μm)	43 750	45 420	48 500	8	0	0
Organism (≥ 10-50 μm)	350	716	558	5	5	6
Heterotrophic bacteria (cells/mL)	22 863	23 363	22 363	310	60	13
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	0	1	0	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

> 32 PSU from 26 November to 1 December

1 cycle 4 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	11.75	11.73	11.74	11.72	11.91	11.92	11.92
pH	8.05	8.06	8.10	8.09	8.03	8.07	8.06
ORP (mV)	577	526	517	528	570	467	495
Salinity (psu)	34.47	34.28	34.51	34.37	34.54	34.53	34.53
DO (mg/L)	8.94	9.07	8.97	8.77	8.88	8.92	8.79
Turbidity (NTU)	7.02	10.30	9.70	9.93	6.74	7.21	7.00
Total suspended solid (mg/L)	23.30	22.67	26.00	24.50	18.40	19.50	26.00
Dissolve organic carbon (mg/L)	1.71	2.65	2.69	2.78	2.78	2.71	2.69
Particulate organic carbon (mg/L)	1.30	1.76	1.35	2.00	1.31	1.30	1.34
Organism (≥ 50 μm)	139 250	170 000	173 750	159 750	0	0	0
Organism (≥ 10-50 μm)	1 639	1 447	1 566	1 206	189	197	190
Heterotrophic bacteria (cells/mL)	16 727	18 333	27 000	27 000	280	155	85
Total coliform (cfu/mL)	0	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	1	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

1 cycle 4 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	10.55	10.52	10.50	10.89	10.60	10.61
pH	7.87	7.90	7.91	7.77	7.81	7.83
ORP (mV)	539	537	538	549	538	543
Salinity (psu)	34.54	34.47	34.54	34.23	34.43	34.39
DO (mg/L)	9.09	9.03	8.98	8.43	8.77	8.79
Turbidity (NTU)	5.73	6.27	7.72	4.05	3.55	3.52
Total suspended solid (mg/L)	19.07	19.30	18.10	15.10	11.90	12.40
Dissolve organic carbon (mg/L)	1.92	1.99	2.00	2.14	2.19	2.17
Particulate organic carbon (mg/L)	0.19	0.34	0.21	0.39	0.50	0.28
Organism (≥ 50 μm)	81 000	60 667	61 917	0	0	2
Organism (≥ 10-50 μm)	331	313	569	3	1	1
Heterotrophic bacteria (cells/mL)	46 863	41 181	35 863	155	75	120
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	12	50	81	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

> 32 PSU from 3 December to 8 December

1 cycle 5 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	11.07	11.17	11.13	11.12	11.20	11.24	11.27
pH	8.07	8.14	8.12	8.12	8.06	8.06	8.06
ORP (mV)	560	517	521	524	552	538	523
Salinity (psu)	34.52	34.59	34.61	34.61	34.54	34.56	34.58
DO (mg/L)	9.07	9.10	8.96	8.79	8.96	8.89	8.85
Turbidity (NTU)	12.90	18.30	17.80	16.90	11.90	12.50	12.30
Total suspended solid (mg/L)	27.50	33.47	37.10	33.60	26.40	25.10	30.10
Dissolve organic carbon (mg/L)	2.85	2.19	2.11	2.15	2.15	2.08	2.16
Particulate organic carbon (mg/L)	1.77	2.27	1.83	1.62	1.29	1.47	1.44
Organism (≥ 50 μm)	509 100	340 900	406 900	288 000	10	16	18
Organism (≥ 10-50 μm)	1 949	1 810	1 794	1 863	206	201	218
Heterotrophic bacteria (cells/mL)	9 409	12 272	14 000	15 227	146	63	26
Total coliform (cfu/mL)	0	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	3	2	3	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

1 cycle 5 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	8.17	8.21	8.25	8.06	7.94	8.02
pH	8.38	8.39	8.40	8.41	8.39	8.40
ORP (mV)	432	430	430	441	441	437
Salinity (psu)	34.56	34.58	34.57	34.42	34.66	34.57
DO (mg/L)	9.36	9.34	9.15	9.42	9.35	9.31
Turbidity (NTU)	12.50	11.40	13.00	6.96	6.26	6.86
Total suspended solid (mg/L)	30.40	28.70	23.70	16.70	21.10	19.60
Dissolve organic carbon (mg/L)	1.97	2.15	2.11	2.11	2.12	2.16
Particulate organic carbon (mg/L)	0.62	1.48	0.72	0.66	0.58	0.43
Organism (≥ 50 μm)	79 400	71 700	63 700	1	1	0
Organism (≥ 10-50 μm)	354	439	490	5	4	1
Heterotrophic bacteria (cells/mL)	31 181	30 090	31 045	300	95	95
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	3	4	3	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

≥ 3-32 PSU PSU from 10 December to 15 December

2 cycle 1 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	10.00	9.86	9.87	9.89	10.23	10.21	10.24
pH	7.42	7.44	7.44	7.45	7.42	7.43	7.43
ORP (mV)	468	458	460	463	459	460	453
Salinity (psu)	23.75	23.74	23.75	23.73	23.60	23.72	23.72
DO (mg/L)	9.41	9.28	9.04	8.84	9.19	8.94	8.87
Turbidity (NTU)	27.10	34.20	33.50	34.80	26.80	29.10	26.00
Total suspended solid (mg/L)	51.30	76.53	73.50	74.10	64.30	65.70	83.20
Dissolve organic carbon (mg/L)	9.60	9.70	9.63	9.77	9.73	9.73	9.49
Particulate organic carbon (mg/L)	14.50	14.90	12.30	12.10	15.80	11.90	15.70
Organism (≥ 50 μm)	436 500	771 000	536 000	641 000	22	3	7
Organism (≥ 10-50 μm)	1 974	1 525	1 491	1 664	126	107	111
Heterotrophic bacteria (cells/mL)	20 227	19 000	27 090	25 909	213	403	430
Total coliform (cfu/mL)	0	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	2	0	1	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

2 cycle 1 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	8.88	8.82	8.78	9.18	9.05	9.04
pH	7.80	7.83	7.84	7.52	7.58	7.66
ORP (mV)	557	553	548	597	586	577
Salinity (psu)	23.55	23.55	23.57	23.43	23.44	23.53
DO (mg/L)	10.07	10.03	9.91	9.92	9.92	9.80
Turbidity (NTU)	13.90	11.90	11.40	4.12	4.33	4.25
Total suspended solid (mg/L)	25.60	30.40	20.50	26.70	30.40	20.50
Dissolve organic carbon (mg/L)	2.73	2.67	2.48	2.67	2.47	2.53
Particulate organic carbon (mg/L)	1.46	1.61	1.62	1.31	1.61	1.33
Organism (≥ 50 μm)	31 000	26 000	33 000	0	0	0
Organism (≥ 10-50 μm)	717	769	766	5	6	8
Heterotrophic bacteria (cells/mL)	81 363	83 818	65 909	80	100	160
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	1	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	20	11	3	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

≥ 3-32 PSU from 17 December to 22 December

2 cycle 2 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	7.72	7.37	7.47	7.52	8.11	7.97	8.02
pH	8.23	8.17	8.16	8.15	8.22	8.18	8.17
ORP (mV)	561	527	528	531	552	529	531
Salinity (psu)	22.94	23.37	23.26	23.31	22.84	22.97	22.92
DO (mg/L)	10.31	10.57	10.37	10.07	10.45	10.35	10.15
Turbidity (NTU)	20.10	19.10	19.40	18.80	21.70	22.80	19.90
Total suspended solid (mg/L)	59.70	56.80	60.10	60.10	27.20	30.40	20.50
Dissolve organic carbon (mg/L)	9.52	9.70	9.58	9.45	9.04	9.57	9.27
Particulate organic carbon (mg/L)	14.50	13.80	14.40	14.90	13.10	14.20	13.80
Organism (≥ 50 μm)	387 000	475 000	653 000	415 000	1	0	1
Organism (≥ 10-50 μm)	1 748	1 701	1 751	1 614	149	132	96
Heterotrophic bacteria (cells/mL)	11 954	17 000	16 227	15 454	60	10	135
Total coliform (cfu/mL)	0	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

2 cycle 2 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	4.83	5.05	4.75	4.86	4.87	4.66
pH	7.86	7.86	7.88	7.68	7.72	7.79
ORP (mV)	510	529	537	578	572	567
Salinity (psu)	23.01	23.06	23.09	22.80	22.87	22.79
DO (mg/L)	11.22	11.01	10.91	11.13	11.05	10.99
Turbidity (NTU)	12.20	11.00	11.40	6.61	6.05	6.68
Total suspended solid (mg/L)	28.00	28.90	28.00	20.10	20.80	20.00
Dissolve organic carbon (mg/L)	4.49	4.71	5.40	5.19	5.19	5.25
Particulate organic carbon (mg/L)	1.12	1.20	0.57	2.50	2.74	2.25
Organism (≥ 50 μm)	5 000	7 000	7 000	1	0	0
Organism (≥ 10-50 μm)	785	804	860	3	3	2
Heterotrophic bacteria (cells/mL)	40 636	35 454	40 681	320	166	13
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	16	8	11	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

≥ 3-32 PSU from 24 December to 29 December

2 cycle 3 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	7.42	6.99	6.91	7.02	7.61	7.63	7.62
pH	8.27	8.18	8.17	8.17	8.26	8.25	8.25
ORP (mV)	574	542	543	542	571	561	532
Salinity (psu)	22.20	21.97	21.99	21.93	22.12	22.20	22.18
DO (mg/L)	10.78	10.85	10.71	10.53	10.71	10.57	10.55
Turbidity (NTU)	20.00	18.90	19.10	18.20	19.10	19.10	19.10
Total suspended solid (mg/L)	61.60	59.60	59.10	56.40	57.20	54.70	58.30
Dissolve organic carbon (mg/L)	9.13	9.14	9.05	9.13	9.19	9.02	9.03
Particulate organic carbon (mg/L)	15.50	14.60	15.80	14.30	14.30	15.20	14.60
Organism (≥ 50 μm)	425 000	395 000	438 000	357 000	30	0	0
Organism (≥ 10-50 μm)	1 593	2 666	2 040	2 657	78	118	184
Heterotrophic bacteria (cells/mL)	13 772	15 045	11 045	10 272	0	0	20
Total coliform (cfu/mL)	3	5	21	26	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

2 cycle 3 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	4.74	4.72	4.71	4.72	4.85	4.98
pH	7.82	7.85	7.88	7.52	7.58	7.63
ORP (mV)	566	564	558	582	578	583
Salinity (psu)	22.03	22.03	22.01	22.14	22.19	22.13
DO (mg/L)	11.29	11.28	11.09	10.85	11.01	10.90
Turbidity (NTU)	3.70	3.87	3.42	4.44	4.72	4.66
Total suspended solid (mg/L)	14.70	14.70	14.00	16.80	14.70	18.00
Dissolve organic carbon (mg/L)	3.83	3.84	3.97	3.98	3.88	3.85
Particulate organic carbon (mg/L)	0.87	0.93	0.97	1.50	1.90	1.56
Organism (≥ 50 μm)	63 000	62 000	56 000	0	0	0
Organism (≥ 10-50 μm)	857	874	894	7	7	7
Heterotrophic bacteria (cells/mL)	21 818	25 772	23 227	230	10	7
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	1	2	1	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

≥ 3-32 PSU from 31 December to 5 January

2 cycle 4 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	5.96	5.13	5.09	5.18	6.03	6.08	6.10
pH	8.29	8.13	8.11	7.99	8.22	8.06	8.15
ORP (mV)	549	546	547	552	553	558	553
Salinity (psu)	22.66	23.00	23.02	22.92	22.65	22.83	22.82
DO (mg/L)	11.09	10.63	10.49	10.43	11.00	10.30	10.51
Turbidity (NTU)	17.80	18.70	18.50	18.00	20.10	18.70	19.40
Total suspended solid (mg/L)	52.90	56.40	56.70	55.30	57.1	57.5	57.5
Dissolve organic carbon (mg/L)	9.50	9.74	9.86	9.66	9.54	9.45	9.56
Particulate organic carbon (mg/L)	13.70	15.60	16.20	15.10	15.60	16.00	15.30
Organism (≥ 50 μm)	307 000	349 000	351 000	304 000	4	0	0
Organism (≥ 10-50 μm)	3 132	3 306	2 107	1 968	138	133	436
Heterotrophic bacteria (cells/mL)	16 090	12 000	12 318	11 590	17	7	3
Total coliform (cfu/mL)	64	31	44	60	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

2 cycle 4 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	4.04	3.95	3.88	3.85	4.02	3.73
pH	7.94	7.85	7.88	7.46	7.69	7.73
ORP (mV)	566	569	563	589	589	585
Salinity (psu)	22.69	22.52	22.71	22.56	22.31	22.57
DO (mg/L)	11.35	10.96	11.16	11.52	11.19	11.23
Turbidity (NTU)	9.14	9.84	9.42	4.10	3.75	3.69
Total suspended solid (mg/L)	34.90	34.10	35.60	11.10	13.90	13.10
Dissolve organic carbon (mg/L)	5.18	5.19	5.08	4.53	4.53	4.48
Particulate organic carbon (mg/L)	7.14	7.97	6.97	1.87	1.85	1.73
Organism (≥ 50 μm)	22 000	26 000	12 000	0	0	0
Organism (≥ 10-50 μm)	740	1 828	992	2	1	3
Heterotrophic bacteria (cells/mL)	17 454	17 409	16 545	180	100	50
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	1	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	8	36	7	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.

≥ 3-32 PSU from 7 January to 12 January

2 cycle 5 Period	Day 0 (Ballasting)						
	S1 (Test water)*	S2 (Control water)			S3 (Treated water)		
		B**	M	E	B	M	E
Water temperature (°C)	4.62	4.18	4.05	4.11	4.95	4.85	4.89
pH	8.23	8.25	8.24	8.23	8.26	8.17	8.25
ORP (mV)	569	556	556	554	573	570	554
Salinity (psu)	23.57	23.51	23.55	23.58	23.45	23.49	23.50
DO (mg/L)	11.52	11.41	11.26	10.92	11.27	11.10	10.98
Turbidity (NTU)	20.90	20.20	19.00	20.10	20.60	20.20	20.80
Total suspended solid (mg/L)	61.60	56.80	55.10	55.70	60.50	60.80	58.30
Dissolve organic carbon (mg/L)	10.30	10.20	10.10	10.10	10.10	9.97	9.94
Particulate organic carbon (mg/L)	16.50	13.50	15.20	14.20	16.80	17.70	16.50
Organism (≥ 50 μm)	301 000	382 000	401 000	381 000	2	2	2
Organism (≥ 10-50 μm)	1 358	1 285	1 442	1 087	99	391	215
Heterotrophic bacteria (cells/mL)	16 863	11 272	8 045	10 818	166	13	7
Total coliform (cfu/mL)	0	3	7	4	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0	0

* Test water represented to including viable organism and organic matter.

** B, beginning; M, middle; E, End.

2 cycle 5 period	Day 5 (De-ballasting)					
	S2 (Control water)			S4 (Treated water)		
	B*	M	E	B	M	E
Water temperature (°C)	3.01	2.97	3.01	3.02	3.08	3.31
pH	7.76	7.80	7.83	7.53	7.67	7.77
ORP (mV)	592	591	587	632	614	596
Salinity (psu)	23.42	23.47	23.47	23.34	22.99	23.25
DO (mg/L)	11.18	10.91	11.13	11.40	11.22	11.24
Turbidity (NTU)	12.80	13.00	11.40	11.70	12.10	12.60
Total suspended solid (mg/L)	37.10	37.30	36.40	33.70	32.70	31.70
Dissolve organic carbon (mg/L)	4.06	4.01	4.10	4.11	4.06	4.05
Particulate organic carbon (mg/L)	8.62	9.23	7.88	7.30	5.46	6.48
Organism (≥ 50 μm)	7 667	7 917	4 917	0	0	0
Organism (≥ 10-50 μm)	912	563	550	1	1	0
Heterotrophic bacteria (cells/mL)	46 545	52 772	35 045	40	23	7
Total coliform (cfu/mL)	0	0	0	0	0	0
Escherichia coli (cfu/100 mL)	0	0	0	0	0	0
Intestinal *Enterococci* (cfu/100 mL)	1	5	7	0	0	0
Vibrio cholerae (cfu/100 mL)	0	0	0	0	0	0

* B, beginning; M, middle; E, End.